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Predicting Onset of Cannabis Use in Early Adolescence: The Interrelation Between High-Intensity Pleasure and Disruptive Behavior. The TRAILS Study*

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ABSTRACT. Objective: Increased knowledge about the mechanisms by which some individuals are at risk for early onset of cannabis use might contribute to the improvement of prevention efforts. We focus on the roles of early-adolescent high-intensity pleasure, disruptive behavior, and their interplay in the prediction of onset of cannabis use 2 years later. **Method:** Data from 81% ($n = 1,804$) of the participants (51.9% girls) of the Tracking Adolescents' Individual Lives Survey (TRAILS), a prospective general population study in the north of The Netherlands, were analyzed. Measures included parent-reported high-intensity pleasure, and parent- and self-reported general disruptive behavior, attention-deficit hyperactivity, oppositional problems, and conduct problems (Child Behavior Checklist/6-18 and Youth Self-Report) at ages 10-12. Onset of

cannabis use was assessed at age 12-14 by means of self-reports. Analyses were carried out in Mplus. **Results:** Early adolescent high-intensity pleasure and disruptive behavior, mainly conduct problems and to some extent attention-deficit hyperactivity, predicted the onset of cannabis use in adolescence. Although we found some mediation by general disruptive behavior, conduct problems, and attention-deficit hyperactivity, the contribution of high-intensity pleasure in predicting the onset of cannabis use was found to be mainly independent from disruptive behavior. **Conclusions:** The unique contribution of both high-intensity pleasure and disruptive behavior points in the direction of different pathways toward onset of cannabis use. (*J. Stud. Alcohol Drugs* 70: 850-858, 2009)

EARLY ONSET OF CANNABIS USE is associated with increased risks for future substance use, abuse, and dependence (Lynskey et al., 2003). Moreover, the rate of drug-related social, legal, emotional, and health problems is highest among those who initiated illicit drug use at age 12 or younger and declines with increased age of initiation (Anthony and Petronis, 1995). Therefore, more insight in the mechanism behind early onset of cannabis use is important and might contribute to early identification of at-risk individuals and to the development of prevention programs.

Previous studies have found prospective associations between certain temperamental and behavioral characteristics and onset of cannabis and illicit substance use in adolescence. The majority of these temperamental characteristics, such as sensation seeking (Teichman et al., 1989) and novelty seeking (Masse and Tremblay, 1997), are associated with one's reaction to and seeking of novel and rewarding stimuli. Although the construct of sensation seeking also incorpo-

rates characteristics of behavioral disinhibition (Zuckerman and Neeb, 1979), the construct of novelty seeking reflects mainly the excitement in response to novel stimuli and the tendency toward exploratory behavior (Cloninger, 1987). Certain behavioral characteristics that have been associated with onset of cannabis and other illicit substance use, such as hyperactivity, impulsivity, and conduct behavior (Elkins et al., 2007; Pedersen et al., 2001), can be classified as disruptive behavior. Although previous research has shown a link between temperamental indicators of sensation seeking and disruptive behavior (Oldehinkel et al., 2004; Ormel et al., 2005; Rettew et al., 2004), their interrelation in predicting the onset of cannabis use remains unclear. To increase the insight into the mechanism behind early onset of cannabis use, we need to understand the roles of sensation-seeking characteristics, disruptive behavior, and their interrelation.

When the focus is on temperamental indicators of sensation seeking, disruptive behavior, and future onset of

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cannabis use, various mechanisms seem plausible. Sensation seeking and disruptive behavior might independently contribute to an increased risk of onset of cannabis use in adolescence. This way, an individual with both sensation-seeking characteristics and disruptive behavior would be most vulnerable to the early onset of cannabis use. Alternatively, the increased vulnerability for onset of cannabis use in adolescents with disruptive behavior might be the result of their increased level of sensation seeking. In this model, sensation seeking modifies the relationship between disruptive behavior and onset of cannabis use. A third possibility is that sensation seeking and disruptive behavior are different points on a same continuum. In this case, the relationship between sensation-seeking characteristics and onset of cannabis use might be mediated by a higher level of disruptive behavior.

Another question with respect to the mechanism behind early onset of cannabis use regards the specific subtypes of disruptive behavior that interrelate with sensation-seeking characteristics in predicting early onset of use. Within the framework of Gray's behavioral inhibition system (BIS) and behavioral activation system (BAS) (Gray, 1982), it has been suggested that sensation-seeking characteristics reflect the activation of the BAS (Panksepp, 1998). High behavioral activation is reflected in heightened sensitivity to cues for reward, which increases behavior toward more rewards. Experimenting with the use of cannabis might be a rewarding experience for those with high BAS functioning. This way, increased BAS activity might explain why certain adolescents are at increased risk for initiating the use of cannabis when compared with others. Whereas oppositional defiant disorder and conduct disorder have been associated with high BAS activation (Quay, 1993), attention-deficit/hyperactivity disorder has been associated with low behavioral inhibition (Barkley, 1997; Iaboni et al., 1997). These findings suggest an interrelation among sensation-seeking characteristics, oppositional problems (OPs), and conduct problems (CPs) but not attention-deficit hyperactivity (ADH), in the prediction of onset of cannabis use.

The Tracking Adolescents' Individual Lives Survey (TRAILS) is a general population study that offers the possibility to find out which of the mechanisms described above underlie the early onset of cannabis use. One of the strengths of TRAILS is that information about its participants is gathered from multiple informants. Because of differences in contexts and perspective, different informants provide partly unique information about the participants' behavior (Renouf and Kovacs, 1994). Moreover, observation by different informants rules out common method variance as an interpretation of the findings.

The aims of the present study are to prospectively investigate the following: (1) the predictive value of both high-intensity pleasure—a temperament dimension based on the construct of sensation seeking that emphasizes physical and social thrill seeking (Capaldi and Rothbart, 1992)—and

disruptive behavior in early adolescence on the onset of cannabis use in adolescence and (2) the mechanism by which high-intensity pleasure, disruptive behavior, and future onset of cannabis use interrelate. We focus on the nature of the interrelation (independent effects, moderation, mediation) and on which subtypes of disruptive behavior—ADH, OPs, and CPs—interrelate with high-intensity pleasure in predicting the onset of cannabis use.

Method

Sample

The present study reports data from the first (Time 1 [T1]) and second (Time 2 [T2]) assessment wave of TRAILS, which ran from March 2001 to July 2002 and from September 2003 to December 2004, respectively. A detailed description of the sampling procedure and methods is provided in De Winter et al. (2005).

Briefly, the TRAILS target sample involved all 10- to 11-year-old children living in the three largest cities and some rural areas in the north of The Netherlands. Of the eligible children, 76.0% ($N = 2,230$, mean [SD] age = 11.09 [0.55]; 50.8% girls) were enrolled in the study (i.e., both child and parent gave informed consent to participate). Responders and nonresponders did not differ with respect to the prevalence of teacher-rated problem behavior and the associations between sociodemographic variables and mental health indicators (De Winter et al., 2005).

Of the 2,230 baseline (T1) participants, 96.4% ($n = 2,149$; 51.2% girls) participated in the first follow-up assessment (T2), which was held 2-3 years after T1 (mean number of months = 29.44, [5.37]). Mean (SD) age at T2 was 13.55 (0.54). For the analyses of the present study, subjects who reported onset of cannabis use before the assessment of temperament had taken place were eliminated from the analyses ($n = 14$). Furthermore, subjects were included only when complete data on the measures outlined below were available ($n = 1,804$). Included participants had a somewhat higher intelligence ($t = 7.96$, 2,219 df, $p < .001$), had a lower level of self-reported CPs ($t = -2.22$, 2,196 df, $p < .05$), had a higher socioeconomic status ($\chi^2 = 81.88$, 1 df, $p < .001$; $n = 2,188$), and were less likely to have a parent with a history of substance-use disorder ($\chi^2 = 13.69$, 1 df, $p < .05$; $n = 2,176$) when compared with the excluded participants ($n = 426$).

Data collection

At T1, one of the parents or guardians (preferably the mother) was asked to fill out a written questionnaire. Besides the questionnaire, well-trained interviewers visited the parents at their homes to administer an interview covering a wide range of topics, including parental psychopathology. Children were assessed at school, where they filled out

questionnaires, in groups, under the supervision of one or more TRAILS assistants. In addition, neurocognitive tasks, intelligence, and a number of biological parameters were assessed individually. Teachers were asked to fill out a brief questionnaire for all TRAILS children in their class.

T2 involved only questionnaires, to be filled out by the adolescents, their parents, and their teachers. As in T1, the adolescents filled out their questionnaires at school, supervised by TRAILS assistants. Confidentiality of the study was emphasized.

Measures

Behavior, temperament, and cannabis use. Disruptive behavior at T1 was assessed by the Child Behavior Checklist (CBCL; Achenbach, 1991a) and Youth Self-Report (YSR; Achenbach, 1991b). Both instruments contain a list of behavioral and emotional problems, which parents and children, respectively, can rate as being not true, somewhat or sometimes true, or very or often true in the past 6 months. For both parent and self-reports, we constructed a composite scale of "general disruptive behavior." This measure represents the mean of the standardized ratings on the Diagnostic and Statistical Manual of Mental Disorders (DSM)-oriented problem scales attention-deficit/hyperactivity disorder, oppositional defiant disorder, and conduct disorder (CBCL: 29 items, Cronbach's $\alpha = .90$; YSR: 27 items, Cronbach's $\alpha = .84$), which correspond to the clinical diagnostic categories (Achenbach et al., 2003; American Psychiatric Association, 1994). In addition to this composite measure, we used the mean standardized ratings on the individual scales attention-deficit/hyperactivity disorder (CBCL: 7 items, Cronbach's $\alpha = .84$; YSR: 7 items, Cronbach's $\alpha = .72$), oppositional defiant disorder (5 items, Cronbach's $\alpha = .71$; YSR: 5 items, Cronbach's $\alpha = .62$), and conduct disorder (17 items, Cronbach's $\alpha = .78$; YSR: 15 items, Cronbach's $\alpha = .72$). None of the problem scales included items that regarded the use of substances.

High-intensity pleasure, defined as "the pleasure derived from activities involving high intensity or novelty" was assessed at T1 by the parent version of the short form of the Early Adolescent Temperament Questionnaire-Revised (EATQ-R; Putnam et al., 2001). The dimension "high-intensity pleasure" was based on the Zuckerman construct of sensation seeking (Capaldi and Rothbart, 1992; Zuckerman and Neeb, 1979). Although the Sensation Seeking Scale Form V, the most widely used version of the Sensation Seeking Scale, differentiates the four subscales of disinhibition, thrill and adventure seeking, experience seeking, and boredom susceptibility, the construct of high-intensity pleasure of the EATQ emphasizes physical and social thrill seeking only. It consists of items (e.g., "wouldn't be afraid to try a risky sport, like deep sea diving"; "expresses a desire to travel to exotic places when s/he hears about them") that are largely

covered by the subscales thrill and adventure seeking and experience seeking of the Sensation Seeking Scale Form V. We used the parent version because its factor structure was superior to that of the child version in our sample (Oldehinkel et al., 2004). The Dutch version of the EATQ-R identifies six temperament dimensions, including high-intensity pleasure (six items, Cronbach's $\alpha = .77$) (Oldehinkel and Hartman, unpublished manuscript).

Onset of cannabis use was assessed at T2 by self-report questionnaires. Adolescents were asked to report the age at onset of cannabis use. Answers were dichotomized into "use" and "no use." Although reliability of self-reports on substance use has been the subject of debate, previous research has concluded that, when anonymity is assured, self-report measures of substance use have acceptable reliability (Murray and Perry, 1987).

Confounding variables. Intelligence was assessed at T1 by the Vocabulary and Block Design subtests (Sattler, 1992) from the Revised Wechsler Intelligence Scales for Children (Van Haasen et al., 1986; Wechsler, 1974).

Socioeconomic status was calculated as the average of income level, educational level, and occupational level of each parent at T1, using the International Standard Classification for Occupations (Ganzeboom and Treiman, 1996), and scored on a 3-point scale.

Onset of tobacco use was assessed at T2 by self-report questionnaires. Adolescents were asked to report the age at onset of tobacco use. Answers were dichotomized into "use" and "no use."

Statistical approach

Means of and correlations between variables were calculated, and gender differences in means and percentages were analyzed by *t* tests and chi-square tests, respectively. All continuous variables were standardized to a mean of 0 and an SD of 1 to obtain internally comparable regression coefficients. All paths were controlled for the possible effects of gender, age, socioeconomic status, and intelligence. Intelligence and socioeconomic status were initially tested as potential confounders, but being not significantly related to cannabis use, they were excluded from the models. As onset of tobacco use is a strong predictor for onset of cannabis use (McCambridge and Strang, 2005), it was added as an outcome variable (multivariate model). In this way, we controlled for the possibility that associations among temperament, disruptive behavior, and cannabis use were spurious because of a shared link with tobacco use. Thus, onset of tobacco use was included as an outcome variable to test the unique association between the predictor variables and onset of cannabis use and was not an outcome of interest.

Subsequent analyses were conducted in three phases and for self-reports and parental reports separately. First, we aimed to test the predictive value of both early adolescent

high-intensity pleasure and general disruptive behavior on onset of cannabis use by specifying an additive model. A multiple regression model, in which both high-intensity pleasure and general disruptive behavior at age 10-12 predicted the onset of cannabis use at age 12-14, was fitted. As cannabis use was treated as a dichotomous variable, a logistic regression model was used. The odds ratios (OR) describe the increase in odds of early onset of cannabis use per increase by one standard deviation in the predictor variable.

Second, we aimed to investigate the possible interrelation between both predictors by specifying two separate models. We started with an interaction-model to test whether high-intensity pleasure served as a modifier in the prospective relationship between general disruptive behavior and onset of cannabis use. Then, we specified a mediation model to test whether the relationship between high-intensity pleasure and onset of cannabis use was mediated by general disruptive behavior. To test mediation, we first specified a direct model, in which onset of cannabis use at age 12-14 was regressed on high-intensity pleasure, in addition to regressing the general disruptive behavior score on high-intensity pleasure. This was done to ascertain that direct effects of high-intensity pleasure to both general disruptive behavior and cannabis onset were present. The direct path from general disruptive behavior to cannabis onset was not specified. We then specified a full mediation model by allowing for the direct path from general disruptive behavior to onset of cannabis use. To test for an indirect effect from high-intensity pleasure to onset of cannabis use via general disruptive behavior, a joint significance test of the indirect paths was used (Baron and Kenny, 1986; MacKinnon et al., 2002; Sobel, 1982).

To determine which of the three models (additive, moderation, mediation) was the best representation of the interrelation among high-intensity pleasure, general disruptive behavior, and onset of cannabis use, model fit was compared using chi-square difference tests for weighted least squares

means and variance adjusted and maximum likelihood means and variance adjusted estimation (Muthén and Muthén, 1998-2007).

In the final phase of the analyses, we examined whether the results of the optimal model from steps 1 and 2 (using a general disruptive behavior score) held for each of the subtypes of disruptive behavior (ADH, OPs, and CPs). To account for comorbidity between ADH, OPs, and CPs, we adjusted for the correlation between the constructs. Thus, we assessed their independent association with onset of cannabis use.

All models were tested in Mplus 5.0 (Muthén and Muthén, 1998-2007).

Results

Descriptive statistics

At age 12-14, 6.3% of the adolescents ($n = 114$) reported onset of cannabis use. Onset of cannabis use was more likely in boys than in girls ($\chi^2 = 4.72$, 1 df, $p = .030$; $n = 1,804$). Percentages or mean scores of the variables and gender differences in percentages and means are shown in Table 1. Correlations between the variables are shown in Table 2.

The predictive value of high-intensity pleasure and general disruptive behavior with regard to onset of cannabis use. In the additive models, higher levels of both high-intensity pleasure (OR = 1.17, 95% confidence interval [CI]: 1.05-1.31, $p < .01$) and general disruptive behavior (self-reports: OR = 1.30, 95% CI: 1.18-1.43, $p < .001$; and parental reports: OR = 1.30, 95% CI: 1.19-1.42, $p < .001$) were associated with a significantly higher risk of onset of cannabis use 2 years later (Table 3). When both predictors were entered into the model, we found a small reduction in the predictive value of high-intensity pleasure, indicating some interrelation between high-intensity pleasure and general disruptive behavior.

TABLE 1. Descriptive statistics

Variable	Boys Mean (SD)	Girls Mean (SD)	Gender difference		
			t or χ^2	df	p
Onset of cannabis use T2	7.6%	5.1%	$\chi^2 = 4.72$	1	.030
High-intensity pleasure T1	3.42 (0.92)	3.21 (0.93)	$t = 4.99$	1,802	.000
Parent report					
Disruptive behavior	0.37 (0.26)	0.27 (0.21)	$t = 8.67$	1,682 ^a	.000
ADH	0.64 (0.48)	0.48 (0.43)	$t = 7.59$	1,736 ^a	.000
OPs	0.63 (0.44)	0.54 (0.39)	$t = 4.73$	1,747 ^a	.000
CPs	0.17 (0.18)	0.10 (0.13)	$t = 9.40$	1,540 ^a	.000
Self-report					
Disruptive behavior	0.39 (0.23)	0.33 (0.19)	$t = 6.12$	1,683 ^a	.000
ADH	0.59 (0.38)	0.58 (0.34)	$t = 0.58$	1,747 ^a	.565
OPs	0.47 (0.36)	0.42 (0.33)	$t = 3.31$	1,744 ^a	.001
CPs	0.27 (0.21)	0.19 (0.15)	$t = 10.33$	1,588 ^a	.000

Notes: T1 = Time 1; T2 = Time 2; ADH = attention-deficit hyperactivity; OPs = oppositional problems; CPs = conduct problems. ^aDegrees of freedom not equal to $n-1$ because of correction for unequal variances.

TABLE 2. Correlation matrix of Time 1 (T1) high-intensity pleasure, T1 disruptive behavior, and Time 2 (T2) onset of cannabis use

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Onset of cannabis use T2									
2. High-intensity pleasure T1 Parent report	.09 ^a								
3. Disruptive behavior	.14 ^a	.10							
4. ADH	.12 ^a	.08	.88						
5. OPs	.11 ^a	.09	.84	.60					
6. CPs	.14 ^a	.09	.87	.59	.67				
Self-report									
7. Disruptive behavior	.13 ^a	.12	.31						
8. ADH	.08 ^a	.08		.31			.81		
9. OPs	.11 ^a	.09			.29		.81	.53	
10. CPs	.14 ^a	.13				.29	.86	.47	.60

Notes: All associations were significant at $p < .001$. ADH = attention-deficit hyperactivity; OPs = oppositional problems; CPs = conduct problems. ^aPoint biserial correlations for associations between a continuous and a dichotomous variable.

The interrelation between high-intensity pleasure and general disruptive behavior in the prediction of onset of cannabis use. Results from the moderation analyses indicated that high-intensity pleasure did not modify the relationship between general disruptive behavior and onset of cannabis use. In other words, the predictive value of general disruptive behavior with regard to the onset of cannabis use did not depend on the level of high-intensity pleasure.

Results from the mediation analyses indicated that high-intensity pleasure was associated with a higher level of general disruptive behavior according to both self-reports ($\beta = 0.10$, 95% CI: 0.06-0.15, $p < .001$) and parental reports ($\beta = 0.10$, 95% CI: 0.06-0.14, $p < .001$) (Table 3). When allowing for the indirect path, findings indicated that there was a small indirect relationship between high-intensity pleasure and onset of cannabis use via general disruptive

behavior (self-reports: OR = 1.03, 95% CI: 1.01-1.04, $p < .001$; parental reports: OR = 1.02, 95% CI: 1.01-1.04, $p < .001$). The direct path from high-intensity pleasure to onset of cannabis use remained almost unchanged (self-reports: OR = 1.16, 95% CI: 1.05-1.29, $p < .01$; parental reports: OR = 1.17, 95% CI: 1.05-1.29, $p < .01$).

Because the additive as well as the mediation model yielded significant results, chi-square difference testing was used to determine which of the models fitted the data best. The mediation model was superior to the additive model according to self-reports ($\chi^2 = 18.73$, 1 df, $p < .001$) and parental reports ($\chi^2 = 21.21$, 1 df, $p < .001$). This indicated that three pathways explained the onset of cannabis use; two direct paths from high-intensity pleasure and general disruptive behavior, and a small indirect path from high-intensity pleasure via general disruptive behavior.

TABLE 3. Effects of Time 1 (T1) high-intensity pleasure and disruptive behavior on onset of cannabis use at Time 2 (T2)

Variable	Onset of cannabis use vs no onset	
	Parental report	Child report
Additive model, OR		
High-intensity pleasure	1.17 [†] (1.05-1.31)	1.17 [†] (1.05-1.31)
Disruptive behavior	1.30 [‡] (1.19-1.42)	1.30 [‡] (1.18-1.43)
Moderation model, OR		
High-intensity pleasure	1.19 [†] (1.06-1.34)	1.18 [†] (1.05-1.33)
Disruptive behavior	1.31 [‡] (1.20-1.43)	1.31 [‡] (1.18-1.45)
High-Intensity Pleasure \times Disruptive Behavior	0.96 (0.89-1.05)	0.98 (0.88-1.08)
Mediation model		
High-intensity pleasure to outcome, OR	1.17 [†] (1.05-1.29)	1.16 [†] (1.05-1.29)
Disruptive behavior to outcome, OR	1.28 [‡] (1.18-1.38)	1.29 [‡] (1.19-1.40)
High-intensity pleasure to disruptive behavior, β	0.10 [‡] (0.06-0.14)	0.10 [‡] (0.06-0.15)
High-intensity pleasure to disruptive behavior to outcome, OR	1.02 [‡] (1.01-1.04)	1.03 [‡] (1.01-1.04)

Notes: Numbers in parentheses are 95% confidence intervals. All continuous variables were standardized to mean = 0 and SD = 1. All values were adjusted for the influence of gender and age and for spurious associations due to a shared link with onset of tobacco use (multivariate models). OR = odds ratio.

[†] $p < .01$; [‡] $p < .001$.

TABLE 4. Effects of T1 high-intensity pleasure and subtypes of disruptive behavior on onset of cannabis use at T2

Mediation model	Onset of cannabis use vs no onset	
	Parental report OR (95% CI)	Child report OR (95% CI)
High-intensity pleasure to outcome, OR	1.17 [†] (1.05-1.29)	1.17 [†] (1.05-1.29)
ADH to outcome, OR	1.17 [†] (1.06-1.28)	—
CPs to outcome, OR	1.14 [†] (1.05-1.23)	1.29 [‡] (1.19-1.40)
High-intensity pleasure to ADH, β	0.08 [‡] (0.04-0.13)	—
High-intensity pleasure to CPs, β	0.08 [‡] (0.04-0.13)	0.10 [‡] (0.05-0.14)
High-intensity pleasure to ADH to outcome, OR	1.01* (1.00-1.02)	—
High-intensity pleasure to CPs to outcome, OR	1.01* (1.00-1.02)	1.02 [†] (1.01-1.04)

Notes: Numbers in parentheses are 95% confidence intervals. All continuous variables were standardized to mean = 0 and SD = 1. All values were adjusted for the influence of gender and age and for spurious associations due to a shared link with onset of tobacco use (multivariate models). OR = odds ratio; ADH = attention-deficit hyperactivity; CP = conduct problems.

* $p < .05$; [†] $p < .01$; [‡] $p < .001$.

The interrelation among high-intensity pleasure, ADH, OPs, and CPs in the prediction of onset of cannabis use. In the third phase, we aimed to study whether the results for the general disruptive behavior score held for each subtype of disruptive behavior (ADH, OPs, and CPs). Correlations between subtypes were taken into account. In the direct models, a higher level of high-intensity pleasure was significantly associated with higher levels of ADH, OPs, and CPs, according to both self-reports and parental reports. β s ranged from 0.07 to 0.10. Subsequently, for each of the informants separately, an indirect model was specified, allowing for the direct paths from ADH, OPs, and CPs to onset of cannabis use, and for the indirect paths from high-intensity pleasure to cannabis onset via ADH, OPs, and CPs.

According to self-reports, and when controlling for the influence of other subtypes of disruptive behavior, ADH and OPs did not predict onset of cannabis use. These predictors were, therefore, excluded from the model. In the final model, CPs predicted the onset of cannabis use (OR = 1.29, 95% CI: 1.19-1.40, $p < .001$) and partially mediated the relationship between high-intensity pleasure and onset of cannabis use (OR = 1.02, 95% CI: 1.01-1.04, $p < .01$) (Table 4). The direct path from high-intensity pleasure to cannabis onset was left nearly unchanged (OR = 1.17, 95% CI: 1.05-1.29, $p < .01$).

According to parental reports, OPs did not predict onset of cannabis use. This problem scale was therefore excluded from the final model, in which ADH (OR = 1.17, 95% CI: 1.06-1.28, $p < .01$) and CPs (OR = 1.14, 95% CI: 1.05-1.23, $p < .01$) predicted onset of cannabis use. Both partially mediated the relationship between high-intensity pleasure and onset of cannabis to a very small extent. Again, the significance of the direct path from high-intensity pleasure to onset of cannabis use remained nearly unchanged (OR = 1.17, 95% CI: 1.05-1.29, $p < .01$).

Although the values of the indirect paths were very small, chi-square difference testing indicated that allowing for the

indirect paths significantly contributed to the model fit of both the model based on child reports ($\chi^2 = 14.77$, 1 df, $p < .001$) and the model based on parental reports ($\chi^2 = 18.10$, 1 df, $p < .001$).

Discussion

The first aim of the present study was to examine the predictive value of a temperamental and a behavioral manifestation of disinhibition at age 10-12 with regard to the onset of cannabis use 2 years later. According to self-reports and parental reports both high-intensity pleasure and general disruptive behavior predicted the onset of cannabis use.

Our findings on temperament are in line with previous studies that investigated the prospective relationship between overlapping measures of temperament—novelty and sensation seeking—and onset of cannabis or illicit substance use in adolescence. In a study of Mâsse and Tremblay (1997), novelty seeking in 6-year-old boys predicted the onset of illicit substance use in early and mid-adolescence. Teichman and colleagues (Teichman et al., 1989) found a prospective relationship between sensation seeking in mid-adolescence and onset of cannabis use in late adolescence. Together these findings suggest that the relationship between one's reactive style toward rewarding and novel stimuli and onset of cannabis use persists from at least early childhood to late adolescence.

Our findings on the prospective association between general disruptive behavior and onset of cannabis use are also in line with previous studies. Findings from the Minnesota Twin Family Study indicate that not only clinical levels of externalizing behavior at age 11 predict onset of cannabis and other substance use at age 14, but so do symptom dimensions of attention-deficit/hyperactivity disorder, oppositional defiant disorder, and conduct disorder (King et al., 2004). Also, Pedersen and colleagues (2001) found that a subclinical level of CPs at age 13 predicts the onset of

cannabis use 2 years later. These findings show that children and adolescents with symptoms of disruptive behavior—and, therefore, not only those with clinical diagnoses—are at increased risk to initiate the use of cannabis.

Our second aim was to examine the interplay between high-intensity pleasure and general disruptive behavior in the prediction of onset of cannabis use. Again the findings from self-reports and parental reports converged. Our results indicated that a mediation model best described the interrelation among high-intensity pleasure, general disruptive behavior, and onset of cannabis use. In this model, there were three pathways to the onset of cannabis use, two direct pathways from high-intensity pleasure and general disruptive behavior, and an indirect pathway from high-intensity pleasure to onset of cannabis use via general disruptive behavior. The coefficient of this latter path indicated that only a very small part of the relationship between high-intensity pleasure and onset of cannabis use was the result of a higher level of general disruptive behavior. Although temperamental characteristics and psychopathology are sometimes viewed as different points on the same continuum, our findings indicate mainly independent contributions to the risk of early onset of cannabis use.

Our third aim was to investigate whether the associations among high-intensity pleasure, general disruptive behavior, and onset of cannabis use held for a specific subtype of disruptive behavior (i.e., ADH, OPs, and CPs), corrected for the overlap between subtypes. This time, findings from parental and self-reports diverged. According to self-reports, only CPs predicted the onset of cannabis use, whereas, according to parental reports, both CPs and ADH predicted onset of cannabis use. To some extent, these findings are in line with the study of Elkins and colleagues (2007), who found that, after adjustment for the overlap between subtypes, both hyperactivity and conduct symptoms at age 11 increased the odds of trying an illicit drug at age 14 by 29% and 60%, respectively. In their study, symptom scores were created by combining mother-reports and self-reports. This methodological difference might explain the divergence with our findings that are based on separate analyses of self-reports and parental reports. Although we found very high agreement between self-reports and parental reports on the general disruptive behavior scale, agreement was somewhat lower when subtypes of disruptive behavior were considered. In our sample, parents reported a lower level of CPs and a somewhat higher level of ADH when compared with self-reports. This might have affected the reciprocal influence between ADH and CPs in the association with onset of cannabis use and might explain why ADH predicted onset of cannabis use according to parental reports only. Discrepancy in findings between parental and self-reports might be explained by differences between informants in the context and perspective in which they observe behavior and is in line with previous research (Verhulst and Van der Ende, 1992). For instance, parents

might perceive hyperactive symptoms in their children as more disturbing than children do, which might explain the higher rate of ADH in parental reports. The lower level of CPs in parental reports might be explained by the fact that parents might be unaware of the rule-breaking behavior of their children. Disruptive behavior may be less apparent at home and, in addition, as teenagers become more autonomous most of them confide less in their parents (Monck, 1991). Conclusively, CPs and to some extent ADH predicted the onset of cannabis use.

Finally, we aimed to examine whether CPs and/or ADH mediated the prospective relationship between high-intensity pleasure and onset of cannabis use. We expected CPs to mediate this relationship, as increased BAS functioning in both novelty-seeking characteristics and CPs (Panksepp, 1998; Quay, 1993) might explain their relationship with onset of cannabis use. According to both self-reports and parental reports, a very small part of the relationship between high-intensity pleasure and onset of cannabis use was, indeed, mediated by CPs. This finding suggests that increased BAS functioning might underlie the onset of cannabis use. Contrary to our expectations, we also found some mediation by ADH, according to parental reports only. Although the predictive value of this indirect path was very small, an explanation for this finding might be considered. As BIS and BAS functioning are assumed to be mutually inhibitory (Gray, 1982) and independent (Gray, 1982; Quay, 1993), different combinations of high and low BIS and BAS are possible. Thus, although ADH is associated with decreased BIS functioning (Iaboni et al., 1997), there is also a certain level of BAS functioning. The latter might explain the mediating role of ADH in the relationship between high-intensity pleasure and onset of cannabis use. On the other hand, although high-intensity pleasure has been associated with increased BAS sensitivity, it also contains a certain level of BIS sensitivity. Therefore, the relationship among high-intensity pleasure, ADH, and onset of cannabis use might indicate a role of the behavioral inhibition system in the onset of cannabis use. Associations among behavioral (dis)inhibition and frequency and onset of cannabis and substance use have been found in previous studies (Bates et al., 1986; Höfler et al., 1999; Mâsse and Tremblay, 1997; Pedersen, 1991; von Sydow et al., 2004). Conclusively, findings indicate mainly independent contributions for high-intensity pleasure, CPs, and to some extent ADH in predicting onset of substance use and a very small indirect relationship between the constructs.

In conclusion, early adolescent high-intensity pleasure and disruptive behavior predicted the onset of cannabis use in adolescence. Although we found some mediation by general disruptive behavior, the contribution of high-intensity pleasure in predicting the onset of cannabis use was found to be mainly independent from disruptive behavior. When subtypes of disruptive behavior were considered, we found that particularly the conduct and attention-deficit/hyperac-

tivity characteristics were related to onset of cannabis use, and that both mediated a very small part of the relationship between high-intensity pleasure and onset of cannabis use.

The present study is not without limitations. First, because temperamental characteristics (such as high-intensity pleasure) are assumed to appear early in life and to have reasonable stability over time (Rothbart and Ahadi, 1994), we assumed high-intensity pleasure to predate the manifestation of disruptive behavior. However, in this study, high-intensity pleasure and disruptive behavior were assessed at the same age. Therefore, based on the currently available data, we were not able to investigate the relation in time between high-intensity pleasure and disruptive behavior, nor could we exclude the possibility that behavioral problems might have affected high-intensity pleasure. Second, behavior problems were based on questionnaire data that do not represent one-to-one counterparts with the DSM-IV (American Psychiatric Association, 1994) criteria of attention-deficit/hyperactivity disorder, oppositional defiant disorder, and conduct disorder. Third, a general population sample is characterized by low prevalence rates of cannabis use, especially because of our young age groups. Fourth, although confidentiality of the study was emphasized, participants might have underreported their use of cannabis. This may have influenced the results. However, because of the importance of studying predictors of cannabis use at an early age, our results contribute to understanding the mechanism behind onset of cannabis use.

Our findings have implications for future research. The unique contribution of both high-intensity pleasure and disruptive behavior points in the direction of different pathways toward onset of cannabis use. These pathways might be differentially affected by genetic liability, might diverge in the progression toward substance abuse, and interactions with other risk factors of substance use, such as peer influence and parenting practices, might differ among pathways. To increase the insight in the mechanism behind early onset of cannabis use, we recommend future research in this area to address these matters.

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